TANK FARM CONTRACTOR OPERATION AND UTILIZATION PLAN

1.0 INTRODUCTION TO THE OPERATING PLAN

This Tank Farm Contractor (TFC) Operation and Utilization Plan (O&UP) updates the *Tank Waste Remediation System Operation and Utilization Plan* (TWRSO&UP), Revision 1 (Kirkbride et al. 1999), using the latest information to model the March 8, 2000, River Protection Project (RPP) Key Planning Assumptions (PIO 2000). This scenario also is identified as Case 3S6E for internal tracking of Hanford Tank Waste Operation Simulator (HTWOS) model scenarios.

1.1 PURPOSE OF THE SIMULATION

The TFC O&UP documents multiple flowsheet scenarios used to validate the formal technical baseline documented in the Readiness-To-Proceed (RTP) effort. The TFC O&UP does not define the baseline; rather, it generates data used to assess the baseline against the input basis and assumptions. The primary scenario, Case 3S6E, was developed to incorporate additional changes to the TWRSO&UP, Revision 1, Case 3 (Kirkbride et al. 1999) to resolve feed staging tank issues, to include changes in assumptions, and to include additional Hanford waste tank system and programmatic constraints in the model. Results from Case 3S6E will be used to confirm the technical baseline, to verify the scope of planned facility upgrades, to direct the development or revision of specifications and supporting engineering studies, to prepare operational plans, and to verify project schedules for feed delivery and product receipt.

1.2 BACKGROUND – THE PRIVATIZATION CONTRACT

In August 1998, the DOE signed contractual obligations with BNFL Inc. to proceed with Part B, Phase 1, of Tank Waste Remediation System (TWRS) privatization. These obligations include staging low-activity waste (LAW) feed, staging high-level waste (HLW) feed, and receiving various final and intermediate waste products and miscellaneous waste streams from the contractor. During the first half of fiscal year (FY) 1999, the U.S. Department of Energy, Richland Operations Office (RL), and BNFL Inc. completed value engineering studies regarding the feed receipt tanks, entrained solids, and the storage of Pretreated Envelope B. Pretreated Envelope B waste is waste that has been processed through the low-activity waste (LAW) pretreatment process to remove radionuclides and is ready for vitrification. The RL issued revised planning guidance (April 1, 1999) that was incorporated in TWRSO&UP, Revision 1, Case 3 (Kirkbride et al. 1999). After Revision 1 was issued, several intermediate cases were developed for the following purposes (details on these intermediate uses were documented as part of the effort they supported and the references are provided below).

- Incorporate the single-shell tank (SST) retrieval program risk-based retrieval strategy (Boston 1999a).

- Provide information to support planning for constrained funding and unconstrained funding planning for FY 2000 Multi-Year Work Plan (MYWP) submittal (LMHC 1999).

- Provide information early in FY 2000 to support the Readiness-To-Proceed 2 (RTP-2) planning effort (Poppiti 1999).

Ongoing negotiations between BNFL Inc. and DOE-ORP and formation of the Project Integration Office (PIO) led to further changes in the feed delivery schedule and DOE-ORP deferred implementation of the HLW blending assumed in the previous cases. These changes have been incorporated into the 2006 Hot Start scenario and into the sensitivity cases built around it.

1.2.1 Programmatic Integration

Use of the HTWOS model to analyze a scenario and produce a staging plan is a central part of related efforts to define the ORP mission and implement the mission through the RPP. Figure 1.2-1 shows how the TFC O&UP fits within the RPP document hierarchy and Figure 1.2-2 shows additional detail about specific relationships within the hierarchy.

1.2.2 Minimum Versus Extended Order Definitions

Several terms are used to define schedule and processing progress in phase 1. These terms and phrases are defined below.

- Phase 1 Contract Completion

  Phase 1 is contractually over from a schedule standpoint on 2/28/18.

- Minimum Order Quantities

  The contract defines the minimum order quantities as 6000 units of LAW waste processed and 600 canisters of HLW processed. It is likely that these quantities will be processed well before the 2018 contract completion date.

- Minimum Order Tanks

  The list of source tanks selected to provide the minimum order quantity plus additional contingency waste is referred to as the minimum order tanks. This contingency waste insures CHG has an adequate supply of feed to stay abreast of the processing contractor rates.

- Extended Order Tanks

  If BNFL Inc. completes processing of the minimum order quantity before the end of the contract, DOE may request additional waste be processed. This period of time is called the extended order period. The tanks processed (with contingency) are referred to as extended order tanks.

Figure 1.2-1. Relationship of TFC Operation and Utilization Plan to River Protection Project Document Hierarchy.

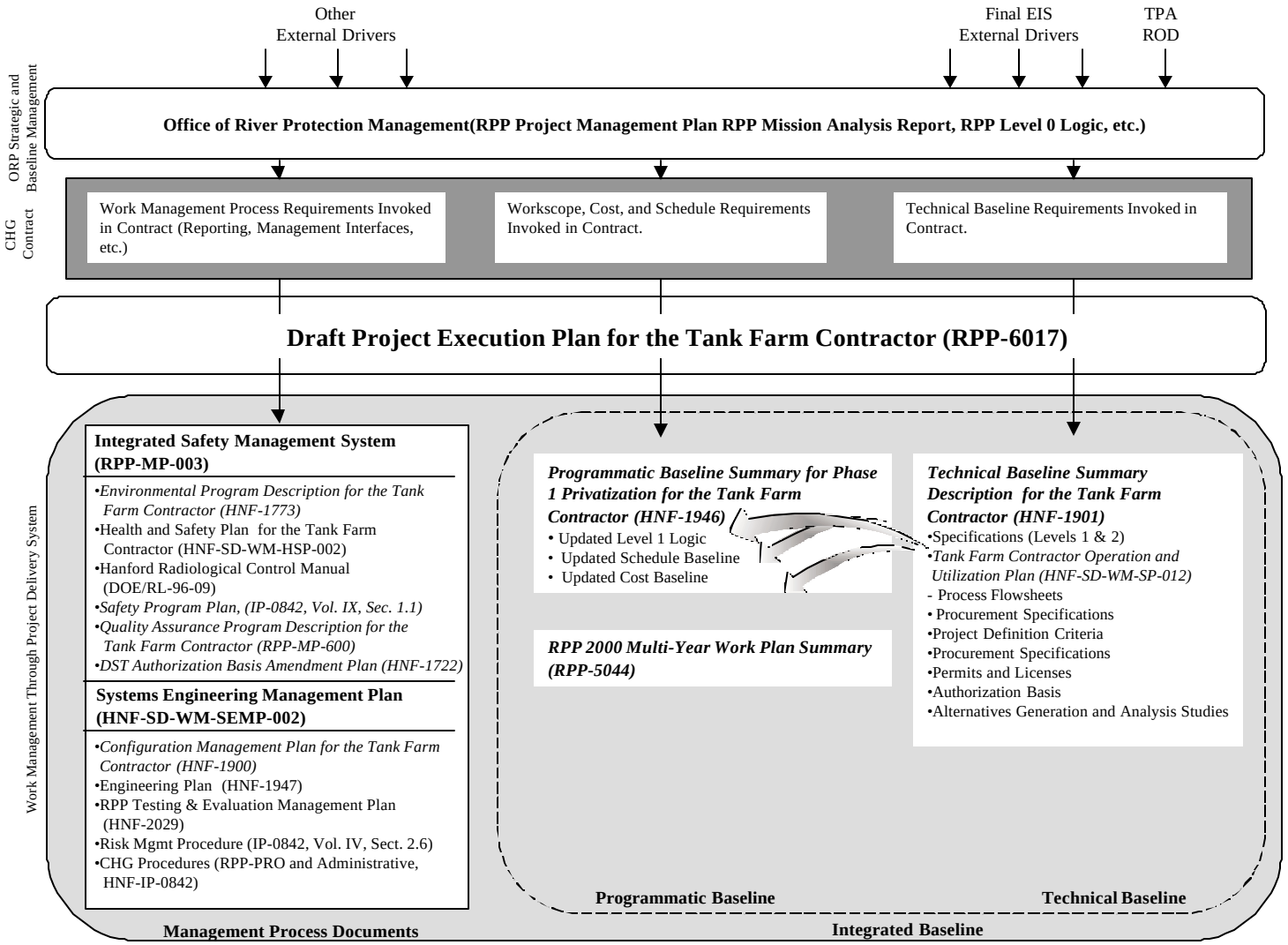
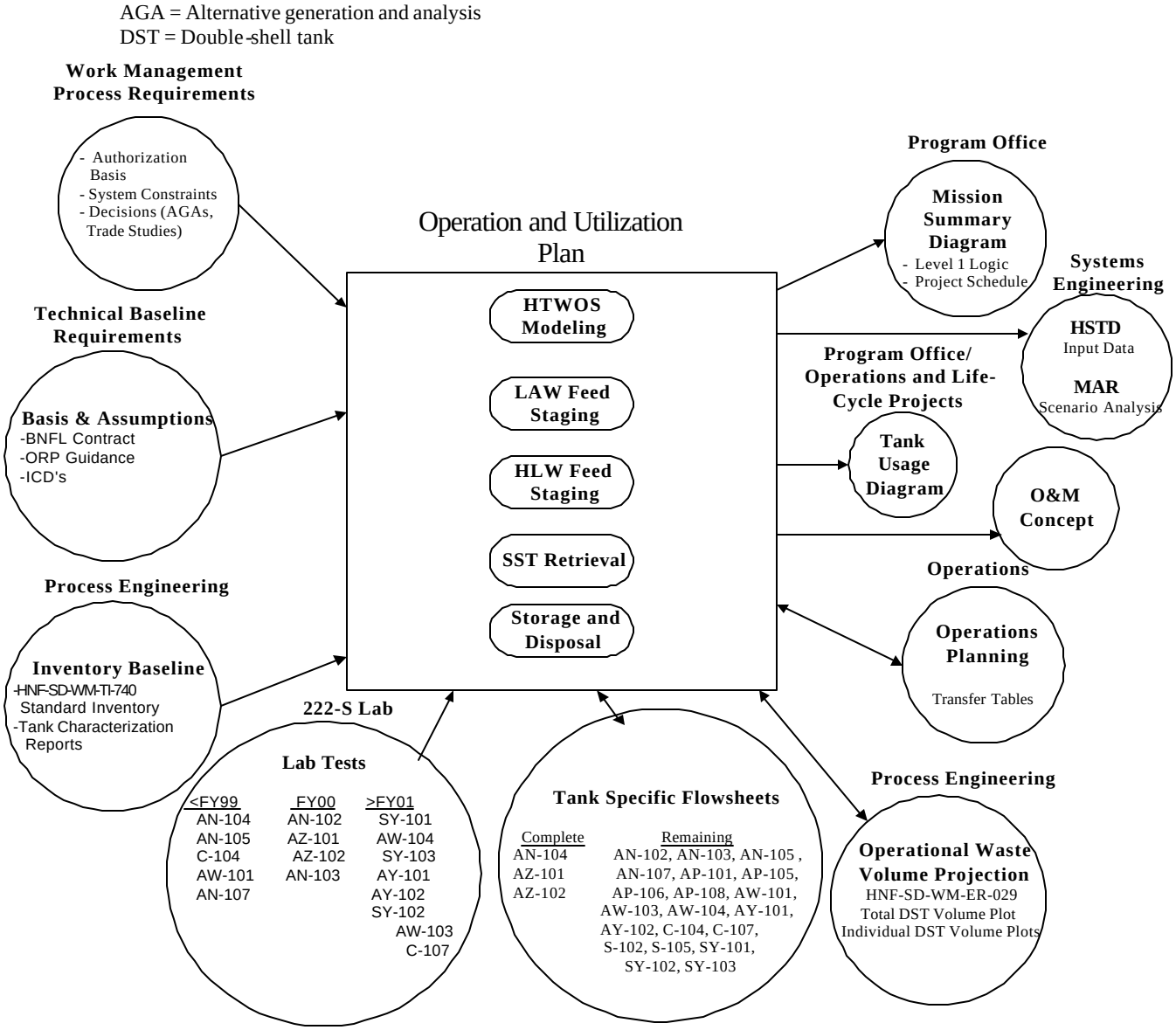


Figure 1.2-2. Relationship of Operation and Utilization Plan to Other River Protection Project Activities.



HLW = High-level waste
HSTD = Hanford Site Technical Database
HTWOS = Hanford Tank Waste Operations Simulator
ICD = Interface control document
LAW = Low-activity waste
MAR = Mission Analysis Report
O&M = Operations and maintenance
ORP = Office of River Protection
SST = Single-shell tank.

1.2.3 Waste Envelope Definitions

Four waste feed envelopes were developed to support the privatization contract (McKee et al. 1995 and Patello et al. 1996). Envelope A, B, and C define Phase 1 LAW feeds and Envelope D defines Phase 1 HLW feed.

- Envelope A represents waste that will test the production capacity and fission product removal efficiency of the plants while producing a final product in which the waste loading will be limited by sodium.

- Envelope B waste is similar to Envelope A but this waste will produce a final product in which the waste loading will be limited by minor component concentrations.

- Envelope C represents waste with complexing agents that may interfere with ^{90}Sr and/or TRU decontamination requiring demonstration of organic destruction or some other acceptable mitigation technology.

- Envelope D defines the HLW solids composition.

1.3 SUMMARY ASSUMPTIONS AND RESULTS

Case 3S6D (the 2006 Hot Start Scenario) implements planning guidance provided by DOE-ORP on January 26 (French 2000) and provides the technical basis for the RTP-2 planning effort. Later, direction was provided on March 8, 2000 (PIO 2000). Although the RTP-2 deliverables could not be adjusted to meet the new guidelines, the differences in the cases are not significant. The March 8, 2000, guidance is accommodated in Case 3S6E.

1.3.1 Case 3S6D Guidance and Assumptions

The following text provides the major assumptions for Case 3S6D. Comparisons in the text are with Case 3, which is documented in the previous revision of the TWRSO&UP (Kirkbride et al. 1999).

1. BNFL Inc. will build its own LAW feed receipt tanks.

2. BNFL Inc. will keep the Envelope B feed (instead of returning it to the double-shell tank [DST] system) and vitrify it early in the sequence using Envelope A sodium loadings.

3. BNFL Inc. will store the entrained solids at its facility rather than returning them to the DST system.

4. The waste in tank 241-AN-102 is delivered before that in tank 241-AN-107. The two tanks exchange places in the LAW feed delivery sequence. Section 3.0 provides a detailed discussion of LAW feed staging.

5. Caustic will be added to the waste in tanks 241-AN-102 and 241-AN-107 to meet corrosion specifications (within available space). The waste will be certified in these tanks and delivered to BNFL Inc. by a direct transfer.

6. Additional staging tanks will be used. Tanks 241-AP-104 and 241-AN-105 will be used to stage LAW feed to BNFL Inc. Tank 241-AY-101 will be used to stage HLW feed to BNFL Inc.

7. The waste in tank 241-C-104, an SST, is delivered as part of the HLW minimum order quantity. Section 4.0 provides a detailed discussion of HLW feed staging.

8. A longer duration is assumed to be needed to certify the feed before delivery to BNFL Inc. than was assumed in previous processing scenarios (seven months for LAW and nine months for HLW).

9. The saltwell liquor volume to be pumped has been reduced from approximately 22,700 m^3 (6 Mgal) to approximately 15,100 m^3 (4 Mgal) and the October 1, 1999 (file SWL_10_1_99R4.itm, cited in Harmsen 1999), pumping schedule is being used.

10. Crust-growth problems in tank 241-SY-101 were mitigated by retrieval and dilution. Mitigation retrieval was assumed to consist of a total of 1,140 m^3 (300,000 gal) of waste retrieved using two transfers. Each transfer was accompanied by equal-volume dilution of the retrieved waste and back dilution of the remaining waste. Retrieval of waste from tank 241-SY-101 started at the same time as and extended past the 3S6D modeling effort. A total of 1,995 m^3 (525,000 gal) of waste has been removed from 241-SY-101 and will be included in future modeling efforts.

11. The 242-A Evaporator campaigns will be scheduled eight months apart with a year-long outage for a life-extension upgrade occurring in FY 2004.

12. The SSTs used for extended-order quantity feed support implementation of the SST program's risk-based retrieval strategy.

13. Extended-order HLW feeds are blended to minimize immobilized high-level waste (IHLW) per DOE direction. No HLW feeds are blended as part of the minimum order quantities.

14. CHG will plan the delivery schedule assuming the sodium delivered from LAW source tanks is the only source of sodium in the LAW glass (i.e., ignore any sodium added by BNFL Inc. during pretreatment or delivered in the HLW slurry carrier liquids; 241-AZ-101 and 241-AZ-102 supernates are LAW sources).

1.3.2 Comparing 3S6D and 3S6E

Case 3S6E implements final planning guidance provided by DOE-ORP (PIO 2000). The following text provides the major differences between Case 3S6E and Case 3S6D. Table 1.3-1 provides a detailed comparison of guidance that defines Case 3S6E and Case 3S6D for Phase 1. Table 1.3-2 provides the same comparison for Phase 2.

1. The same BNFL Inc. start-up schedule as Case 3S6D (2006 Hot Start Scenario)

2. CHG will plan to deliver LAW feed faster (at nearly twice the rate) than BNFL Inc.'s planned LAW treatment ramp up (see Table 1.3-1).

3. BNFL Inc. will vitrify Envelope B feed at low sodium loadings consistent with high sulfate concentrations (no sulfate removal).

4. Phase 2 processing will start March 1, 2018, and will proceed based on an operating efficiency of 60 percent, a LAW melter design capacity of 120 MT glass per day, and a HLW melter design capacity of 12 MT glass per day.

These changes in the guidance between the 2006 Hot Start scenario (Case 3S6D, the basis for RTP-2) and Case 3S6E have no significant impact on the planned Phase 1 feed delivery schedule but do increase the amount of ILAW from 12,500 to 13,500 canisters. The increase is seen in processing the AZ tank supernates as Envelope B LAW waste. The increased LAW ramp-up rate causes the BNFL Inc. ILAW lag storage to fill to 50 percent of capacity by August 2007 or five months sooner than in Case 3S6D.

Table 1.3-1. Comparison of 3S6D and 3S6E Guidance and Results – Phase 1.

Phase 1 Guidance		
Cases	FY 2000 Contract Guidance[1,2,3] (Case 3S6D)	April PIO Planning Guidance[4] (Case 3S6E)
Key Differences	1) Sulfate Removal and 2) 1 times BNFL Inc. Integrated Master Plan Ramp-up Rates for LAW	1) No Sulfate Removal and 2) ~2 times the BNFL Integrated Master Plan Ramp-up Rates for LAW
Low-Activity Waste		
Initiate PT Hot Start	4/30/06	4/30/06
First LAW Delivery AP-101	4/30/06	4/30/06
Initiate LAW Hot Start	11/30/06	11/30/06
Initiate LAW Vit. Services	3/1/08	3/1/08
LAW Treatment Ramp Up -Nominal rate = 754 units/yr -2.38 ILAW packages/day	From – To Units/Yr 11/30/06 – 11/30/07 151(20%) 11/30/07 – 11/30/08 452(60%) 11/30/08 – 11/30/09 754(100%) Through Ext. Order 1100(146%)	From – To Units/Yr 11/30/06 – 11/30/07 279(37%) 11/30/07 – 11/30/08 830(110%) 11/30/08 – 11/30/09 1011(134%) Through Ext. Order 1100(146%)
BNFL Inc. Sulfate Removal -Na_2O Loading in Envelope B	Yes 19.5 wt.%	No 7.5 wt.%
Product Return Starts When BNFL Inc. Lag Storage is X% Full	(ILAW/IHLW) 50%/50%[5]	(ILAW/IHLW) 50%/50%
High-Level Waste		
First HLW Delivery AZ-101	10/31/06	10/31/06
Initiate HLW Hot Start	5/31/07	5/31/07
Initiate HLW Vit. Services	9/1/08	9/1/08
HLW Treatment Ramp Up -Nominal rate = 102 cans/yr -0.28 IHLW canisters/day	From – To # Canisters 9/1/08 – 8/31/09 41(40%) Through Ext. Order 120(117%)	From – To # Canisters 9/1/08 – 8/31/09 41(40%) Through Ext. Order 120(117%)
HLW Waste Oxide Loading	Glass Properties Model Calc.	Glass Properties Model Calc.
Phase 1 Projections Through the BNFL Inc. Contract Period (2/28/18)		
#ILAW Packages	12,500	13,500
#IHLW Packages	1,060	1,070
Date When BNFL Lag Product Storage is 50% Full	ILAW – January 2008 IHLW – April 2009	ILAW – August 2007 IHLW – April 2009
LAW Feed Delivery Dates	All tanks are delivered on the same dates for both cases	
HLW Feed Delivery Dates	All tanks are delivered on the same dates for both cases	

FY = Fiscal year
HLW = High-level waste
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
PIO = Project Integration Office
[1]Multi-Year Work Plan Update Guidance for FY2000 (Erickson 1999)
[2]Lockheed Martin Hanford Corporation Work Authorization for FY 2000 (ORP 1999)
[3]Mission Planning Guidance for FY 2002 (ORP 2000)
[4]Project Integration Office April 2000 Guidance (PIO 2000)
[5]Appendix A Modeling Assumption A6.13.

Table 1.3-2. Comparison of 3S6D and 3S6E Guidance and Results – Phase 2.

Phase 2 Guidance		
Cases	FY 2000 Contract Guidance[1,2,3] (Case 3S6D)	April PIO Planning Guidance[4] (Case 3S6E)
Key Differences	2X/4X LAW/HLW Phase 2 Rates	4X/8X LAW/HLW Phase 2 Rates
Vitrification Rates	2X LAW/4X HLW Phase 1 rates	~4X LAW/8X HLW Phase 1 rates
Na_2O Loading in ILAW	20 wt.%	20 wt.%
Phase 2 Projections		
LAW Completion	March 2042	September 2031
HLW Completion	April 2043	May 2032
Total ILAW Production (# ILAW Packages)	63,200	64,100
Total IHLW Production (# IHLW Canisters)	12,600	12,700

FY = Fiscal year
HLW = High-level waste
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
[1]Multi-Year Work Plan Update Guidance for FY 2000 (Erickson 1999b)
[2]Lockheed Martin Hanford Corporation Work Authorization for FY 2000 (ORP 1999)
[3]Mission Planning Guidance for FY 2002 (ORP 2000)
[4]Project Integration Office April 2000 Guidance (PIO 2000).

Figure 1.3-1. Low-Activity Waste Feed Staging Diagram.

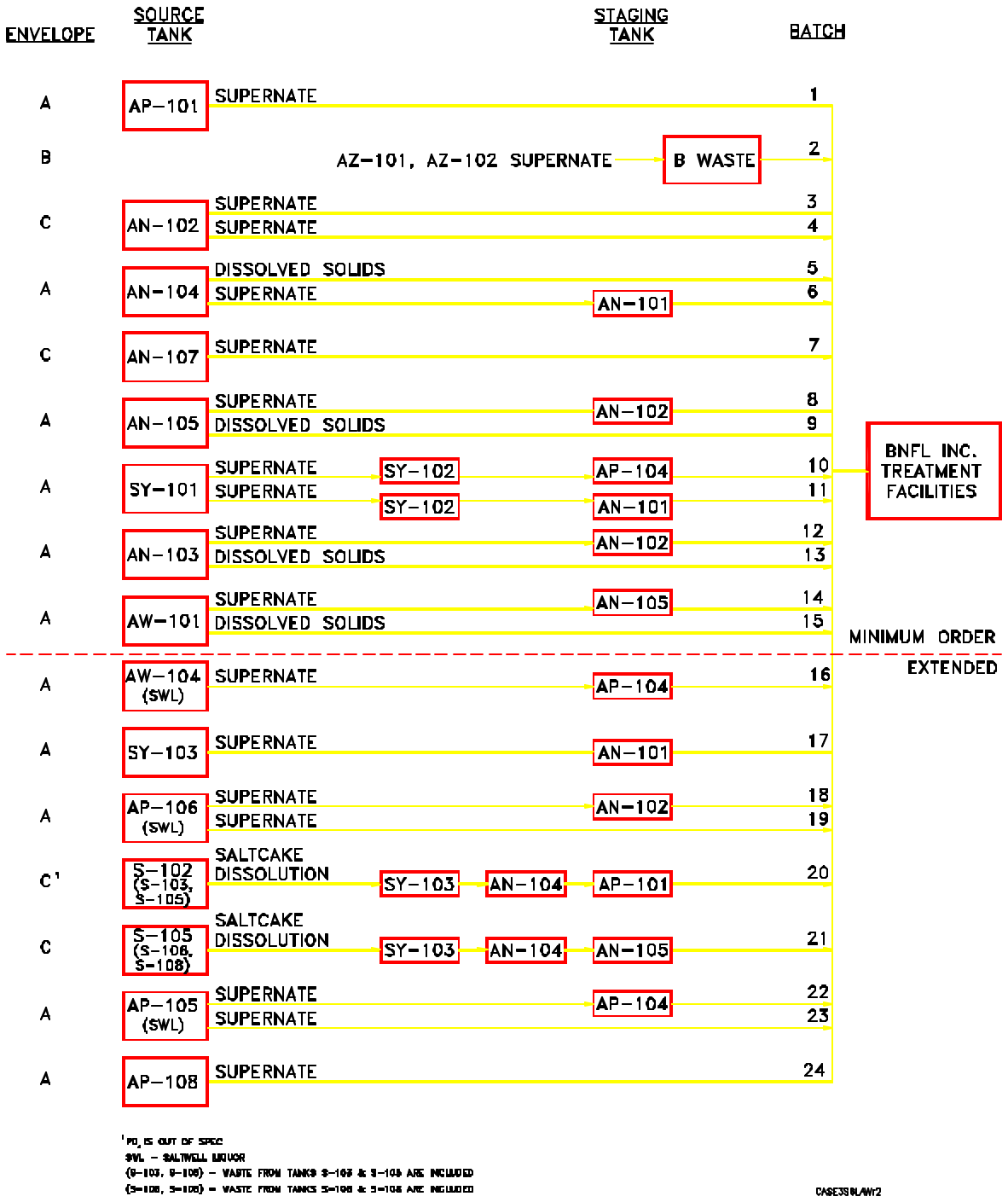
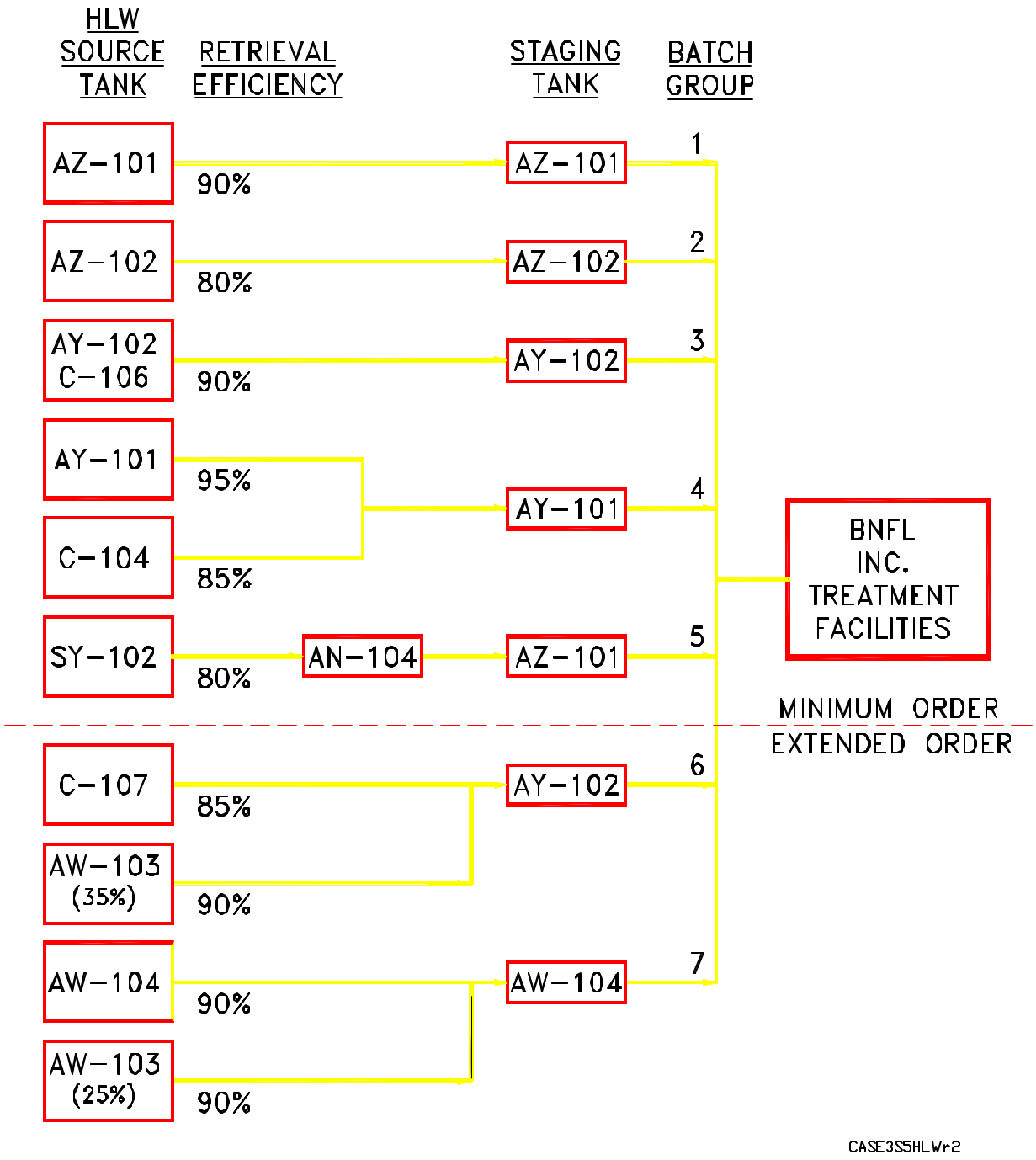


Figure 1.3-2. High-Level Waste Feed Staging - Case 3S6E.



HLW = High-level waste.

Phase 1 Progress

Completion of the minimum order quantity achieves about thirteen percent of the total mission on a volume basis, eleven percent of the total mission by mass of ILAW and five percent of the mission by mass of IHLW. Additional information is shown in Table 1.3-3.

Table 1.3-3. Phase 1 Processing Progress (3S6E).

		Minimum order contract quantities 6000 units LAW 600 canisters HLW	End of Phase 1 contract processing 02/28/18	Completion of Minimum and Extended Order tanks	Total mission[a] Phase 1 and 2
LAW	Mass of Waste[b] (dry basis, MT)	16,340	32,440	36,380	177,000
	Curies immobilized[c]	6.45E+05	9.28E+05	1.02E+06	5.44E+06
	Mass of ILAW (MT)	42,260	77,500	85,700	380,000
HLW	Mass of Waste[b] (dry basis, MT)	1,040	1,640	2,090	23,740
	Curies immobilized[c]	4.66E+07	5.92E+07	6.76E+07	2.23E+08
	Mass of IHLW (MT)	1,840	3,260	4,370	38,930
Total	In-situ volume[d] %	27,250 m^3 13.5%	48,450 m^3 24.2%	59,050 m^3 29.6%	199,850 m^3
	Curies[c] %	4.72E+07 20.7%	6.01E+07 26.4%	6.87E+07 30.1%	2.28E+08
	Number of DSTs	10	16	19	28
	Number of SSTs	2	5[e]	5	149

[a]Does not include Cs and Sr capsules processed in Phase 2 (1.78E+08 Ci, decayed to 1/1/1994).
[b]As delivered to private contractors.
[c]Radionuclides decayed to 1/1/1994.
[d]Hanlon volumes (September 30, 1999) for waste delivered minus fraction left behind (Hanlon 1999a).
[e]Does not include other SSTs retrieved to "backfill" DSTs and that contribute to Phase 1 feed as a result of blending during simultaneous retrievals.
[f]6000 units of LAW for Case 3S6E processed by 6/13/13.
[g]600 canisters of HLW for Case 3S6E processed by 4/21/14.

1.3.3 Compliance with Feed Delivery Guidance (3S6E)

Tables for LAW and HLW from the PIO Guidance are shown below (Tables 1.3-4 and 1.3-5) with the modeling results for units delivered at the delivery date.

Table 1.3-4. Low-Activity Waste.

PIO Guidance				Results	
Delivery sequence	Source tank	Expected envelope	Estimated delivered quantity (units)	Modeled units delivered	Modeled delivery date
1	AP-101	A	615	615	04/29/06
2	AZ-101	B	869	866	07/08/07
3	AZ-102	B	447	445	03/29/08
4	AN-102	C	1112	1112	04/10/08
5	AN-104	A	845	845	09/29/10
6	AN-107	C	808	808	07/08/11
7	AN-105	A	839	839	04/01/12
8[a]	SY-101	A	826	827	01/16/13
9	AN-103	A	1084	1084	10/08/13
10	AW-101	A	1070	1070	10/04/14

LAW = Low-activity Waste

PIO = Project Integration Office

[a]Minimum delivery order of 6000 units is reached during processing SY-101 waste. The subsequent tanks provide contingency waste feed.

Table 1.3-5. High-Level Waste.

PIO Guidance				Results	
Delivery sequence	Source tank[(a)]	Expected envelope	Estimated delivered quantity (canisters)[(b)]	Modeled delivery quantity (canisters)	Modeled delivery date
1	AZ-101	D	81	81	09/01/05
2	AZ-102	D	123	123	02/01/08
3	AY-102	D	191	191	10/01/10
4[(c)]	C-104 and AY-101	D	343	343	06/01/12
5	SY-102	D	226	227	04/01/15

HLW = High-level waste

PIO = Project Integration Office

[a] Sodium in supernates in AY-102, C-104/AY-101, and SY-102 is not included in the estimated quantity of low-activity waste (LAW).

[b] Includes impacts of strontium and manganese additions for pretreating Envelope C waste, use of the Pacific Northwest National Laboratory (PNNL) Glass Properties Model, and results of sludge washing testing for predicting waste loading in glass.

[c]The minimum delivery order of 600 canisters is reached during processing C-104/AY-101 waste. The subsequent tank provides contingency waste feed.

The contract specifications for HLW and LAW waste were originally based on known tank characterization data in the 1994 time frame. New characterization data and new feed source tanks make some batches out of specification. Adjustments to meet specifications prior to delivery through blending, dilution, or treatment are not practical due to cost and technical viability. The contract specification will eventually have to be adjusted to bracket the waste in the tanks.

Clause H43 in the contract requires a treatability determination by BNFL Inc. based on technical ability to process the waste, facility permits, and the facility safety authorization basis. Current waste inventories must be checked to determine if the processing features can accommodate them even though they may be out of specification in some cases.

Item 25 in the PIO Guidance (PIO 2000) states that "all LAW and HLW feed delivered by CHG will be accepted and processed by BNFL Inc. unless the waste does not meet permitting and/or authorization basis requirements for the BNFL Inc. facilities ORP will develop an approach for compensating BNFL Inc. for accepting nearly all off-specification waste. No more than one staged tank of LAW or HLW will be rejected by BNFL Inc. CHG will prepare for retaining a maximum of one rejected staged tank of LAW feed or one rejected staged tank of HLW feed within the DST system during the Minimum Order."

Details of the specification compliance issue for LAW and HLW are discussed in Sections 3.1.3 and 4.1.3 respectively. Batches are compared to the specifications on the basis of compositions projected to be present in the staging tank at the time of delivery. Key issues are summarized in Table 1.3-6 and in the text below.

Table 1.3-6. Specification Compliance (Minimum Order Tanks).

		Off-Specification	
Waste	Batch/Tank	Chemicals	Radionuclides
LAW-B	2A/AZ-101 Supernatant	N/A	TRU, ^{60}Co, ^{90}Sr
LAW-B	2B/AZ-102 Supernatant	SO_4	TRU, ^{154}Eu + ^{155}Eu
LAW-C	7/AN-107	N/A	TRU, ^{154}Eu + ^{155}Eu
HLW-D	4/AY-101 + C-104	N/A	^{233}U
HLW-D	6/C-107 + AW-103	V	N/A
HLW-D	7/AW-104 + AW-103	V	N/A

Envelope D feed is projected to be out of specification in batch groups 4, 6, and 7 each in a single component. Batch Group 4 has a concentration of ^{233}U seven times the limit. Batch Groups 6 and 7 may have elevated vanadium concentrations of 100 percent and 5 percent above the limit. The reported vanadium concentrations are based on "less than" values from sample analyses and, therefore, should be viewed as upper bounds.

The supernatants used to slurry each batch of HLW solids to BNFL Inc. are least apt to fit the current LAW envelope. The current delivery guidance and plan both include the AZ supernatants (LAW batch 2A and 2B). However, the remaining supernatants are assumed to be sent to BNFL Inc., not returned, not counted in feed delivery quantities, and not addressed by PIO (2000). The model run for Case 3S6E assumes these feeds are stored indefinitely by BNFL Inc.

In summary, the contract specification should be adjusted to bracket the Phase 1 wastes. If the BNFL Inc. treatability study excludes some feeds, the sequences should be adjusted.

1.4 PROGRAMMATIC SENSITIVITIES

The results from Case 3S6E show that CH2MHILL Hanford Group, Inc. (CHG) can support the privatization contract by delivering waste feed to BNFL Inc. in accordance with the direction provided by DOE-ORP (PIO 2000). CHG can meet the feed delivery requirements in the contract within the physical constraints of the existing DST system and within the planned upgrades to the DST system. The excess DST space available for SST retrieval during Phase 1 was identified and used to support a risk-based retrieval strategy. Case 3S6D, which differs from 3S6E by how BNFL Inc. handles LAW Envelope B feeds, provides the technical basis for the detailed RTP-2 planning effort. A comparison of these two cases is provided in Section 1.3.

The sensitivity of the mission outcome to changes in key technical assumptions was assessed by running the HTWOS model with revised assumptions and comparing the results from the sensitivity cases to the baseline results. Descriptions of cases analyzed for this sensitivity analysis are shown in Table 1.4-1 and Figure 1.4-1. The major findings from this sensitivity analysis are summarized below in Table 1.4-2. Additional details are discussed in Sections 1.4.1, 1.4.2, and 1.4.3, and in appropriate topical sections of this document. Results from Case 3S6E are provided in the discussions below as a reference for the comparisons.

Major attributes of the sensitivity analyses include start dates for BNFL Inc. pretreatment and vitrification services, delivery dates of first LAW and HLW feed batches, ramp-up rates for LAW and HLW treatment, and sodium oxide (Na_2O) loading in ILAW. Four major cases shown in Table 1.4-1 have two primary differences that distinguish the cases, including start dates and flowsheets. Cases 3S6E and 3S6C form conservative planning bases for waste feed delivery by assuming DOE-ORP flowsheet conditions that minimize the amount of ILAW and IHLW produced by BNFL Inc.

Table 1.4-1. Sensitivity Case Attributes.

	50% Trend - Case 3S6A	90% Current - Case 3S6B	50% Trend - Case 3S6C	90% Trend - Case 3S6E
	Integrated BNFL Inc.		WFD Planning[1]	
Initiate Pretreatment Hot Start	5/31/05	9/30/06	5/31/05	4/30/06
AP-101 Delivery[2]	5/31/05	9/30/06	5/31/05	4/30/06
Initiate LAW Hot Start	7/31/05	12/31/06	7/31/05	11/30/06
Initiate LAW Vit. Services	7/31/06	12/31/07	7/31/06	3/1/08
LAW Treatment Ramp Up[3]	From – To MT ILAW/day 7/31/05 – 7/31/06 4.28(30%) 7/31/06 – 7/31/07 8.57(60%) Through Min. Order 14.28[4](100%) Through Ext. Order 20.85(146%)	From – To MT ILAW/day 12/31/07 – 12/31/08 4.28(30%) 12/31/08 – 12/31/09 8.57(60%) Through Min. Order 14.28(100%) Through Ext. Order 20.85(146%)	From – To Units/Yr 7/31/05 – 7/31/06 226(30%) 7/31/06 – 7/31/07 452(60%) 7/31/07 – 7/31/08 754(100%) Through Ext. Order 1100(146%)	From – To Units/Yr 11/30/06 – 11/30/07 279(37%) 11/30/07 – 11/30/08 830(110%) 11/30/08 – 11/30/09 1011(134%) Through Ext. Order 1100(146%)
Na_2O Loading	$Na_2O \times SO_3 < i$; i=5(A,C); i=8(B)	$Na_2O \times SO_3 < i$; i=5(A,C); i=8(B)	A, B, C: 0.195, 0.075, 0.17	A, B, C: 0.195, 0.075, 0.17
Units/MT Na	A, B, C: 1.0, 2.6, 1.15	A, B, C: 1.0, 2.6, 1.15	A, B, C: 1.0, 2.6, 1.15	A, B, C: 1.0, 2.6, 1.15
Product Return Starts When BNFL Lag Storage is X% full (ILAW/IHLW)	50%/50%	50%/50%	50%/50%	50%/50%
AZ-101 Delivery[2]	9/30/05	1/31/07	9/30/05	10/31/06
Initiate HLW Hot Start	1/31/06	2/28/08	1/31/06	5/31/07
Initiate HLW Vit. Services	3/31/07	3/31/08	3/31/07	9/1/08
HLW Treatment Ramp Up[5]	From – To # Canisters 3/31/07 – 3/30/08 20(20%) 3/31/08 – 3/30/09 102(100%) Through Min. Order 102[4](100%) Through Ext. Order 120(117%)	From – To # Canisters 3/31/08 – 3/30/09 20(20%) 3/31/09 – 3/30/10 102(100%) Through Min. Order 102(100%) Through Ext. Order 120(117%)	From – To # Canisters 3/31/07 – 3/30/08 20(20%) 3/31/08 – 3/30/09 102(100%) Through Ext. Order 120(117%)	From – To # Canisters 9/1/08 – 8/31/09 41(40%) Through Ext. Order 120(117%)
HLW WOL	Glass Properties Model Calc.	Glass Properties Model Calc.	Glass Properties Model Calc.	Glass Properties Model Calc.

HLW = High-level waste ILAW = Immobilized low-activity waste WOL = Waste oxide loading
IHLW = Immobilized high-level waste WFD = Waste Feed Delivery

[1]There are several differences between WFD Planning scenarios and the BNFL Inc. Integrated scenarios that provide a conservative basis for WFD: a) Higher ILAW Na_2O loading in BNFL Inc. Basis of Design than new BNFL Inc. experimental data supports (no sulfate removal in all cases), b) a 2X increase in the HLW ramp up rate and a 1.8X increase in the LAW ramp up rate for Case 3S6E compared to BNFL Inc. ramp up rates in the 3/8/00 PIO assumptions document, c) indefinite storage of LAW entrained solids, d) indefinite storage of HLW pretreatment wash solutions, e) higher maximum capacities during minimum order processing (1100 Units/Yr Vs 754 Units/Yr and 120 HLW canisters/Yr Vs 102 canisters), f) LAW vitrification rates do not include treatment of sodium in the liquid fraction of HLW slurry feed (except for Env. B feed) nor the sodium from HLW solids washing which is inconsistent with BNFL Inc. contract Specification 12.2.7, g) LAW vitrification rates also do not include the addition of sodium by BNFL Inc. during LAW pretreatment, and h) caustic leach factors for tanks C-104 and C-106 are different than experimental leach factors determined by BNFL Inc., which may result in less IHLW glass produced.

[2]Delivery dates shown are completion of the delivery with start of delivery two months prior to completion.

[3]LAW rates are given as units of waste processed during the period, as an annual rate for extended periods (754 or 1,100), or in parentheses as a percentage of BNFL's capacity.

[4]Nominal vitrification rates are based on 2.38 LAW containers/day at 6.0 MT ILAW/container and 0.28 IHLW canisters/day at 3.06 MT/canister.

[5]HLW rates are given as canisters of glass produced during the period, as an annual production rate (102 or 120) for extended periods, or in parentheses as a percentage of BNFL Inc.'s capacity.

Assumptions of minimum glass production per unit feed increases the apparent rate that tank waste must be fed to the treatment facilities. Cases 3S6A and 3S6B are labeled Integrated BNFL Inc. cases because they more closely represent integrated flowsheet cases by including some major side streams generated during processing in BNFL Inc. facilities. The major streams are (1) sodium from HLW feed that will be processed through the LAW melters, and (2) entrained solids separated from LAW feed that will be processed through the HLW melters. Other minor flowsheet related differences between WFD Planning cases and Integrated BNFL Inc. cases are shown in footnote 1 of Table 1.4-1. Cases 3S6A and 3S6C have earlier BNFL Inc. start dates than Cases 3S6B and 3S6E, respectively.

Figure 1.4-1 provides further refinement of sensitivity analysis definition. Case 3S6B R2 was analyzed to evaluate the impact of new proposed BNFL Inc. minimum Na_2O loadings in ILAW. Case 3S6B R3 evaluates the impact of sulfate concentration limitations on the quantity of ILAW produced and subsequent Phase 2 completion dates. Case 3S6E Specification 1 assumes the waste loading in IHLW follows the minimum requirement set forth in Specification 1 of BNFL Inc.'s contract (RL 1996). Case 3S6E R2.1 evaluates the ability to balance the HLW and LAW Phase 2 plant capacities so the completion times are closer. Case 3S6E R2.2 evaluates the processing capacity needed to complete the Phase 2 mission by 2028. Case 3S6E R2.3 evaluates the impact of increasing SST retrieval rates on SST blending (quantity of products) and Phase 2 retrieval completion dates. Case 3S6E R2.4 evaluates the use of tank specific leach factors on HLW during Phase 2.

1.4.1 Phase 1 Feed Staging

Vitrification of LAW feed delivered through the last tank in the minimum order sequence is completed by September 2015 producing a total of 9,830 immobilized low-activity waste (ILAW packages) for the planning case 3S6E (March 8 PIO Guidance Case). The effect of changes in key assumptions on the ILAW package count and the completion date for the minimum order tanks are given in Table 1.4-2.

Figure 1.4-1. Sensitivity Case Definition.

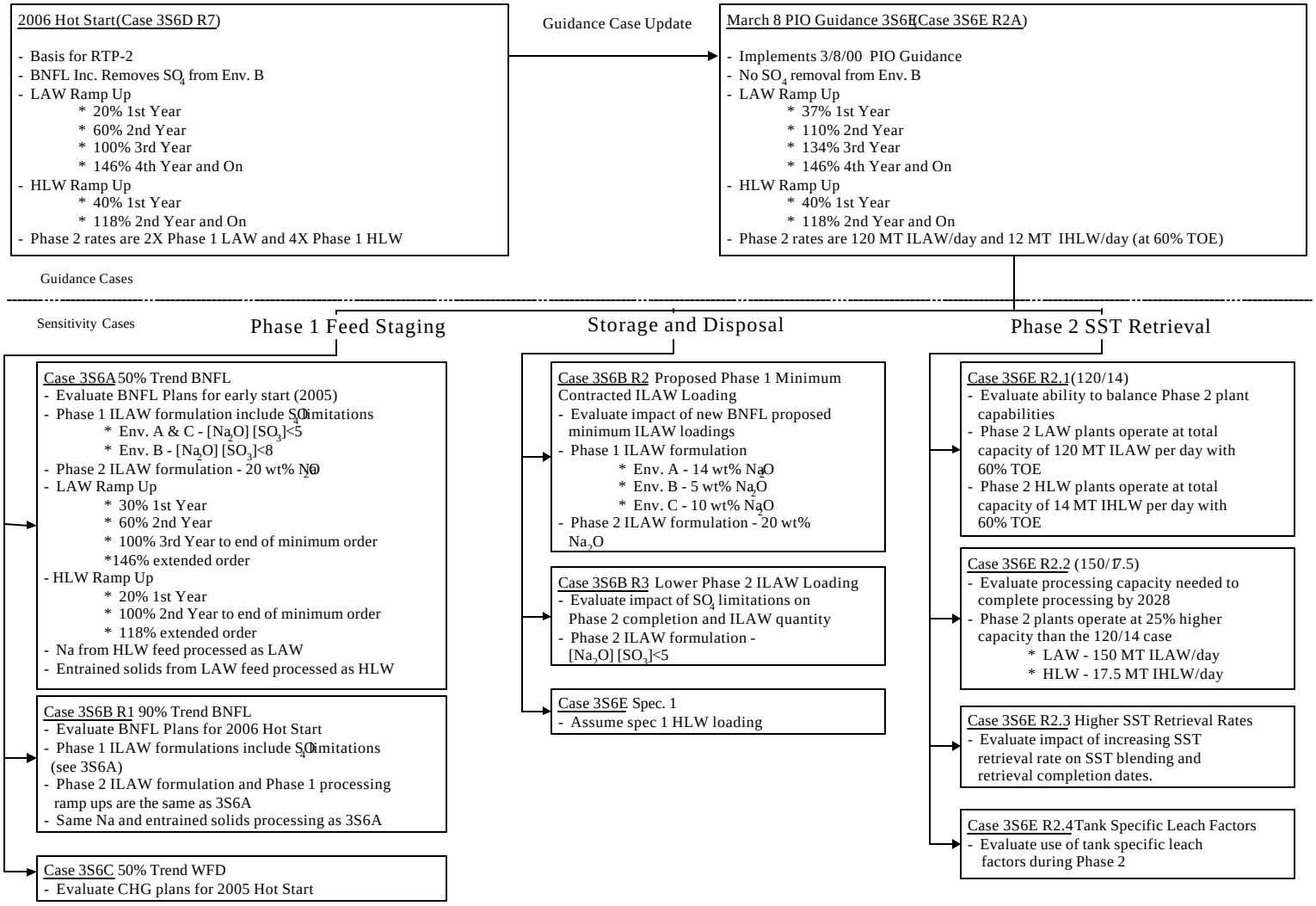


Table 1.4-2. Sensitivity Analysis Summary Results.

Case	Phase 1[1]		Total mission			
	# ILAW packages	# HLW canisters	# ILAW packages	# HLW canisters	Vitrification completion	
					LAW	HLW
Guidance Cases						
3S6E R2A	13,500	1,070	64,100	12,700	Sep. 2031	May 2032
3S6D R7	12,500	1,060	63,200	12,600	Mar. 2042	Apr. 2043
Phase 1 Feed Staging Cases						
3S6A	10,700	1,500	67,000	12,900	Oct. 2032	Jul. 2033
3S6B R1	7,900	990	66,800	12,500	May 2033	Feb. 2034
3S6C	14,400	1,420	64,100	12.500	Nov. 2031	Apr. 2032
Storage and Disposal						
3S6B R2	11,000	990	73,500	12,600	Apr. 2034	Dec. 2034
3S6B R3	7,900	990	99,000	12,400	Jun. 2039	Dec. 2039
3S6E Spec1	13,500	1,070	64,100	17,500	Mar. 2036	Jun. 2037
Phase 2 SST Retrieval						
3S6E R2.1	13,500	1,070	64,300	12,700	May 2030	Nov. 2030
3S6E R2.2	13,500	1,070	64,600	12,800	May. 2028	Aug. 2028
3S6E R2.3	13,500	1,070	64,000	13,400	Oct. 2032	Jun. 2033
3S6E R2.4	13,500	1,070	64,400	24,700	Dec. 2043	Nov. 2045
	Shaded cells indicate major differences from Case 3S6E R2A.					

HLW = High-level waste
IHLW = Immobilized high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
[1]Quantities of ILAW and IHLW produced by the end of the BNFL Inc. contract period, February 28, 2018.

Table 1.4-3. Low-Activity Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the results of implementing March 8, 2000 PIO guidance (planning case).	None – Produce 9,830 ILAW canister by September 2015 from minimum order feed tanks.
Case 3S6D R7 Sulfate removal	This is the 2006 "hot" start case and CHG delivery system could support BNFL LAW process. Case 3S6D represents a scenario with sulfate removal capacity, therefore, increasing sodium oxide loading (0.195, 0.195, and 0.17 for Envelopes A, B, and C, respectively) thus creating less glass. The ramp-up rate is about 1.8 times slower than Case 3S6E.	Decrease the number of ILAW packages by 1,049 assuming feed from minimum order tanks. A negligible change in the completion date because the slower ramp-up rate is offset by the decrease in the amount of ILAW produced.
Case 3S6C 50% Trend WFD Early start	This case evaluates the CHG plans for 2005 hot start. This case starts LAW delivery 11 months earlier than Case 3S6E.	No changes in number of ILAW packages and accelerate completion of LAW minimum order feed tanks by 11 months
Case 3S6B R1 Wash Na from HLW Processing	Additional LAW feed is generated from liquids in HLW feed and HLW sludge washing.	Increases number of ILAW packages by 915 and delays completion by nine months relative to the LAW feed from minimum order tanks.

CHG = CH2MHILL Hanford Group, Inc.
HLW = High-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste.

Vitrification of HLW feed delivered through the last tank in the minimum order sequence (241-SY-102 in Figure 1.3-2), is completed by May 2017 producing a total of 960 IHLW canisters for the planning case 3S6E (March 8 PIO Guidance case). The effect of changes to key assumptions on the IHLW canister count and completion dates for the minimum order feed tanks are given in Table 1.4-3. The following sensitivities are compared to the planning case 3S6E.

Table 1.4-4. High-Level Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the result of implementing March 8, 2000 PIO guidance (planning case).	None – Produce 960 IHLW canisters by May 2017 assuming feed from minimum order tank.
Case 3S6E R2A Blending Option for 241-SY-102	The option of blending 40 percent of 241-AW-103 sludge (currently not planned for vitrification during Phase 1) with 241-SY-102 sludge is expected to increase the waste oxide loading in the blended waste. Blending may decrease the total number of IHLW canisters produced from these tanks by 200 at a life-cycle cost reduction of $2 to 3 million per canister.	Phase 1 tanks would increase feed for IHLW by 120 canisters and the corresponding contingency processing duration of 12 months. Overall mission reduction of 200 canisters and accelerate completion by 20 months.
Case 3S6E R2A Blending of manganese and strontium precipitates	If manganese and strontium precipitates produced from the pretreatment of Envelope C LAW waste are not blended with HLW feed (disposed as separate waste form or vitrified separately), then the amount of HLW glass BNFL Inc. produces could decrease. The planning case assumes blending of the precipitates with HLW feed.	Decrease IHLW by 60 canisters and accelerate completion by six months if disposed of as separate waste form. Insufficient information is available to authors at this time to quantify IHLW produced by separate vitrification.
Case 3S6B R1 Entrained solids	BNFL Inc. treatment of LAW entrained solids with HLW feed would have a minor impact on the amount of IHLW glass produced.	Increase IHLW by 10 canisters and delay completion of minimum order tanks by one month.
Case 3S6B R1 Slower ramp-up	Decreasing the HLW processing ramp-up rate to match the BNFL Inc. plan for ramp-up rate would defer IHLW production and delivery of later HLW feed tanks.	No change to IHLW quantity and delay completion of minimum order tanks by nine months.
Case 3S6C Early start	The effect of starting HLW vitrification 17 months earlier than Case 3S6E is expected to be negligible since this schedule was supported during fiscal year 1999.	No change to IHLW quantity and accelerate completion of minimum order tanks by 17 months.

HLW = High-level waste
IHLW = Immobilized high-level waste
LAW = Low-activity waste.

1.4.2 Phase 2 Single-Shell Tank Retrieval

Phase 2 SST retrieval is projected from the model to complete in June 2028 and processing to complete in February 2032. A total of 64,100 ILAW packages and 12,700 IHLW canisters are produced at the end of the mission from processing all of the wastes in the DSTs and SSTs. The effect of changes in key assumptions on SST retrieval completion dates, immobilized product quantities, and mission completion dates are given in Table 1.4-5.

Table 1.4-5. Phase 2 Single-Shell Tank Retrieval Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2.1 Increase HLW processing capacity from 12 to 14 MT IHLW per day	Phase 2 HLW processing capacity effects LAW melter operating efficiency and completion dates.	LAW melter efficiency increased 12 percent to 96 percent of desired capacity. SST retrieval completes 13 months earlier. Phase 2 mission completes 17 months earlier.
Case 3S6E R2.2 Increase LAW processing capacity to 150 MT per day and HLW processing capacity to 17.5 MT per day (from 120 MT/day and 12 MT/day respectively.	Phase 2 processing capacities effect completion dates for SST retrieval and waste processing.	SST retrieval completes 23 months earlier. Waste processing completes 42 months earlier.
Case 3S6E R2.3 Increase SST retrieval rates.	SST retrieval rates effect SST waste blending and SST retrieval completion dates.	Processing and SST waste retrieval do not complete earlier when SST retrieval rates are increased. Processing rates used in the planning case (3S6E R2A) are the primary constraints for determining completion dates.
Case 3S6E R2.4 Use tank-specific leach factors instead of global leach factors in Phase 2 HLW sludge pretreatment.	Leach factor data effect quantity of IHLW produced and processing completion dates due to differences in chromium removal efficiencies.	SST waste retrieval completes 12 years later. HLW and LAW processing complete 14 and 12 years later, respectively. The amount of IHLW for the entire mission doubled with only a negligible increase in ILAW.

HLW = High-level waste
IHLW = Immobilize high-level waste
ILAW = Immobilized low-activity waste
LAW = Low-activity waste
SST = Single-shell tank.

1.4.3 Storage and Disposal

The effect of changes in key assumptions on quantities of immobilized product produced and the schedule for receipt are given in Table 1.4-6.

Table 1.4-6. Storage and Disposal Sensitivities. (2 Sheets)

Description	Sensitivity	Ramification
Case 3S6E R2A March 8,2000 PIO Guidance	Implements March 8, 2000 PIO Guidance (planning case).	- The Phase 2 LAW vitrification facility is significantly underutilized due to a process rate imbalance between the HLW and LAW vitrification plants. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2007 and 4/2/2009 respectively.
Case 3S6E R2A Spec. 1 The waste oxide loading of HLW glass is less than that projected by the Glass Properties Model	The waste oxide loading of HLW glass only meets the minimum limits specified by Specification 1 of the contract.	- The number of IHLW canisters is significantly increased due to the low waste loading in Specification 1 of the contract. - The Phase 2 LAW vitrification facility is significantly underutilized due to a process rate imbalance between the HLW and LAW vitrification plants. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2007 and 4/2/2009 respectively.
Case 3S6E R2.1 Increased Phase 2 HLW vitrification rates from 12 to 14 MT/day.	The design rates of the LAW and HLW vitrification plants are set at 120 MT/d glass and 14 MT/d glass respectively.	- Few of the ILAW vitrification production outages apparent in Phase 2 Case 3S6E remain, indicating that the 120/14 ratio is near optimum - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2007 and 4/2/2009 respectively.
Case 3S6B R1 BNFL Inc. proposed schedule, ramp-up rates and flowsheet.	This scenario imposes the condition specified in Case 3S6B	- BNFL Inc. will fill the IHLW in-plant storage space in June 2009. Three months prior to assumed initial shipping date of September 2009. - Significantly fewer ILAW packages are made in Phase 1 relative to Case 3S6E. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 11/10/2008 and 4/14/2009 respectively.
Case 3S6B R3 Sulfate impacts to LAW glass are imposed on Phase 2.	The Phase 2 LAW glass is limited by the following condition [wt% Na_2O][wt% SO_3} $\leq$ 5.	- BNFL Inc. will fill the IHLW in-plant storage space in June 2009. Three months prior to the assumed initial shipping date September 2009. - The number of ILAW packages made in Phase 2 increases significantly. - The Phase 2 LAW vitrification facility is significantly underutilized. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 11/10/2008 and 4/14/2009 respectively.
Case 3S6B R2 The waste oxide loading of LAW glass is less than that stated in the BNFL Inc. flowsheet.	During Phase 1 the waste oxide loading of LAW glass only meets the minimum contract limits proposed by BNFL Inc. The Phase 2 waste oxide loading is 20 wt% Na_2O.	- A significant increase in the Phase 1 LAW vitrification rate is needed to meet the minimum contract order. - The number of ILAW packages made is increased significantly. - BNFL Inc. will fill the IHLW in-plant storage space in June 2009. Three months prior to the assumed initial shipping date of September 2009. - BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 8/13/2008 and 4/14/2009 respectively.
Case 3S6A 50% Trend BNFL Planning Assumptions.	Evaluates BNFL plans for a 2005 hot start	- BNFL Inc. will fill the ILAW and IHLW in-plant storage space in December 2006 and June 2008 respectively. These dates are 12 and 15 months prior to the assumed initial shipping dates of December 2007 and September 2009.

Table 1.4-6. Storage and Disposal Sensitivities. (2 Sheets)

Description	Sensitivity	Ramification
		- BNFL Inc. fills 50% of in-plant storage space for ILAW and IHLW by 6/11/2006 and 4/13/2008 respectively.

HLW = High-level waste
IHLW = Immobilized low-activity waste
ILAW = Immobilized high-level waste
LAW = Low-activity waste.

1.5 KEY FINDINGS

A summary of findings from each major section of the document are listed below. The purpose is to highlight the findings of the work that identify: (1) noteworthy accomplishments, (2) the need for further integration or engineering work, and (3) new issues for possible addition to the program's issues management process and critical risk list.

1.5.1 General

- Late Changes in RTP-2 Guidance – The TFC O&UP plan is based on guidance received in on March 8 (PIO 2000). There were no significant ramifications in the late guidance relative to the program planning baseline. Feed delivery dates did not change. (See discussion in Section 1.3.1.)

- Contingency in Feed Delivery – A number of guidance features (PIO 2000) and assumptions ensure that project upgrades are in place in advance of feed delivery actions. These are visible on the mission summary diagram schedule (Figure 3.2-1) and discussed in the notes on Table 1.4-1. In addition, the staging strategy has been modified so that feeds are available from multiple sources in the event a failure occurs in a tank or a farm. This contingency provides good assurance that feed delivery will not result in an idle facility penalty for shutting down a processing facility.

- Flowsheet Variables – The quantity of glass produced (and the processing schedule) are influenced by uncertainties in waste inventory characterization, retrieval efficiencies, blending strategies, HLW solids wash/leach factors, and key glass loading concentrations. Sensitivity cases have been run to bracket these variables such that where uncertainties exist, the impacts are understood (i.e., cases with and without sulfate removal have different, but predictable, glass volumes). Glass quantities and schedules are generally reliable for Phase 1. (See summary discussion in Section 1.4.)

1.5.2 Low-Activity Waste Waste Feed Staging

– Meeting LAW Feed Specifications - The current tank sequence may not comply with the contract specifications for every tank. These issues appear to be manageable and can probably be resolved by expanding the specification limits to fit the waste feeds after the processing impacts are reviewed. (See summary in Section 1.3.4 and discussion in Section 3.1.3)

– Watch List Tanks – Six of the eleven Envelope A feeds are on the watch list for flammable gas concerns. Transfer of waste from these tanks requires written approval by Nuclear Safety and DOE. On the other hand, transfer of waste *into* a watch-list tank requires written approval by the Secretary of Energy. These actions are part of the planned baseline for RTP2, but success is not solely under the control of the Tank Farm Contractor. (See discussion in Section 3.2.1).

– HLW Supernates - The supernatants used to slurry each batch of HLW solids to BNFL Inc. are least apt to fit the current LAW envelope. The current delivery guidance and plan both include the AZ supernatants (LAW batch 2A and 2B). However, the remaining supernatants are assumed to be sent to BNFL Inc., not returned, not counted in feed delivery quantities, and not addressed by PIO (2000). The model run for Case 3S6E assumes these feeds are stored by BNFL Inc. during Phase 1 and processed during Phase 2.

1.5.3 High-Level Waste Feed Staging

– Meeting HLW Feed Specifications - The current tank sequence may not comply with the contract specifications for every tank. These issues appear to be manageable and can probably be resolved by expanding the specification limits to fit the waste feeds after the processing impacts are reviewed by BNFL Inc. (See summary in Section 1.3.4 and discussion in Section 4.1.3.)

1.5.4 Phase 2 Feed Staging

– Risk Based Retrieval Sequence – SST retrieval is prioritized in 10 categories to retrieve tanks that: (1) have the greatest environmental hazard (high ^{99}Tc), and (2) least complicated to retrieve (leaking tanks last). The sequence is optimized to keep LAW and HLW feed balanced to avoid processing shutdowns and to enhance incidental blending that occurs during retrieval. (See discussion in Section 5.2.)

– Number of Simultaneous Retrievals – Case 3S6E is based on a Phase 2 processing rate that enables completion of the mission by 2032. The modeling assumes seven simultaneous retrieval machines are available for operation (RTP-1 assumed a maximum of 5). This assumption is used for all cases. Retrieval does not constrain processing in any case. The risk based retrieval sequence does add

simultaneous retrievals per farm and per quadrant. (See discussion in Section 5.1.1.)

1.5.5 Product Receipt Storage and Disposal

– Product Return Dates – The PIO guidance (PIO 2000) for both HLW and LAW product returns are premised on start dates, rates, and 50 percent filling of the BNFL, Inc. storage capacity. This information was a basis to model a return date. The program planning baseline for RPT-2 is based on prior guidance (Cusack 2000). TFC storage and disposal facilities are available to support product returns under the program planning baseline, but BNFL Inc. interim storage facilities are projected to be over 50 percent full. (See discussion in Section 6.0.)

– 90 Day Storage – RCRA requires a maximum 90 day storage on IHLW canisters and ILAW packages unless BNFL, Inc. delists the waste or obtains permits for dangerous waste storage. The current scenarios exceed 90 days for the start of product returns. BNFL Inc. does expect to be successful in delisting the waste or gaining a permit for dangerous waste storage. (See discussion in Section 6.0.)

1.5.6 Double-Shell Tank Space Management

– DST Design Life – The PIO guidance assumes a DST's will reach the end of their design life and fail at a rate of one for each five years past the design life in Phase 2. This assumption has no impact on completion of processing for Case 3S6E. DST space does not constrain the feed delivery system once the initial batches are transferred. Impacts of specific failures on feed delivery are manageable. (See discussion in Section 7.5.)

– Product Returns – Case 3S6E assumes (per PIO 2000) no return streams from BNFL, Inc. and existing spare space in the DSTs provides adequate space to pump waste from BNFL Inc.'s facilities should an emergency arise. This guidance relieves peak tank space concerns just prior to initial feed delivery and must be preserved. The routings and provisions to make transfers back to the tank farms are still intact.

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